Food mixture or ingredient sources for dietary calcium: Shifts in food group contributions using four grouping protocols

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ABSTRACT

Identifying dietary sources of nutrients by assigning survey foods to food groups can under- or overestimate the contribution a group makes to the intake of specific nutrients. Using calcium and food intakes from USDA's 1994-1996, 1998 Continuing Survey of Food Intakes by Individuals, the authors determined the proportion of dietary calcium from the dairy, grains, meats, fruits, and vegetables groups using four grouping protocols. Calcium contributions from milk and cheese were higher as more ingredient sources and fewer survey food items were represented in the dairy group. Milk, cheese, and yogurt reported as separate survey food items contributed 42% of total calcium intake. An additional 21% of dietary calcium came from dairy ingredients in mixed foods such as macaroni and cheese, pizza, sandwiches, and desserts. The remaining dietary calcium sources were single grains (16%); vegetable (7%); meat, poultry, and fish (5%); fruit (3%); and miscellaneous foods (7%). Data quantifying the nutrient contributions from dairy ingredients could affect dietary guidance messages or research using dairy foods as variables. *J Am Diet Assoc. 2003;103:1513-1519.*

Nutrients from mixed (multiple-ingredient) foods such as pizza or ice cream are traditionally assigned to major food groups with nutrients from single-ingredient foods such as flour, cheese, or milk. Mixture assignments are usually based on the predominant ingredient in each food. This approach hides nutrient contributions from each mixture ingredient. Thus, some foods or groups are identified as important[1] nutrient sources (1) when the contributions are less than represented. However, if each mixture ingredient was assigned to its appropriate group, the ranked importance of some food group sources for nutrients would shift compared with the group rankings when nutrients from the mixtures were assigned. For example, macaroni and cheese is traditionally assigned to the grain group (2). Because most of the calcium in this mixed food is from milk and cheese, the proportion of total calcium intake attributed to grain foods will be overestimated

[1]Batcher et al (1) defined important or rich nutrient sources as food groups providing at least 5% of the total nutrient intake to the population at large and good nutrient sources as food groups providing at least 10% of the 1980 US RDA in a typical serving.

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while the proportion attributed to dairy foods will be underestimated. To meet specific research objectives, researchers have reassigned survey foods to select mixture groups to meet their research objectives (3,4) or used survey recipe data and other ingredient data to estimate the nutrient contributions from mixture ingredients (5-7). Estimates of ingredient intakes are also needed for developing dietary guidance materials, monitoring nutrient intakes, making regulatory decisions affecting food safety (8), and tracking the Healthy People 2010 objectives (9) on the variety and consumption of grains, vegetables, and fruits and objectives for nutrients (including calcium) that are consumed in amounts too low to meet the dietary needs for many sex/age groups. Murphy and Cardoso (10) identified methodological issues that arise when ingredient data on food mixtures is unavailable to international researchers for assessing health risks and food safety concerns.

Beginning with data from the 1987-1988 Nationwide Food Consumption Survey, the US Department of Agriculture (USDA) has been developing databases and analytical procedures to identify ingredients of the major grain and meat/poultry/fish mixtures (11). Ingredient-level data also was used to estimate the number of Food Guide Pyramid servings from foods (12-15), portion sizes (gram weight) for foods commonly eaten (16), and commodity amounts consumed (17). Over time, the methods developed for these databases and analyses have become more systematic. The USDA Continuing Survey of Food Intakes by Individuals (CSFII) recipe and nutrient databases (2) provide a consistent foundation for documenting the translation of survey food data to information on the ingredients and commodities. Additional research databases constructed by USDA from these foundational sources provide multiple options for assigning nutrients from food mixtures or their ingredients to specified groups.

The purpose of this report is to demonstrate that differences among food group contributions to total calcium intakes can be measured by using national estimates of calcium consumption grouped by four distinct protocols. Documentation for these protocols have been released with food intake databases or used for research reported in peer-reviewed journals (2,6,7,14,15,17,18). The protocols vary in the extent by which calcium from survey foods, survey foods and ingredients of mixtures, or ingredients of all survey foods were assigned to food groups. Such information is needed to increase understanding of food sources of dietary nutrients using all available sources, including hidden mixture ingredients. To the best of our knowledge, this study is the first to use a comprehensive, multiple-level database to determine and compare nutrient (calcium) sources by four unique grouping protocols.

METHODS

Food and Calcium Intake Data Sources

Two-day average calcium intakes for 18,071 persons aged two years of age and older (excluding breastfed children), in USDA's 1994-1996 and 1998 CSFII database were used (2). The 1998 data were for children nine years of age and under. The CSFII is a nationally representative sample of noninstitutionalized persons residing in households in the United States. More information on the methods used to collect and code the dietary intakes is available elsewhere (19).

The CSFII technical support files (ie, the recipe and nutrient databases) released with the survey intake data (2), USDA's Nutrient Database (NDB) for Standard Reference (20), and the research ingredient and commodity files maintained in the USDA computerized food-data linkage system FoodLink (21) were used to determine food and ingredient sources of dietary calcium.

Mixtures, Ingredients, Commodities Defined

A total of 9,394 codes represented the unique mixed and single foods reported by the study sample. Mixed foods include sandwiches, soups, stews, salads, macaroni and cheese, pizza, and even foods with only two or three ingredients such as fried chicken, sweetened fruit, buttered kale, or french fried potatoes. Foods such as bread, cheese sauces, desserts, and snacks are often assigned to a single food group; however, some research requires ingredient-level data from these foods. Commodities are single ingredient foods that are from one agricultural source, such as milk, ground beef, flour, and cocoa.

Sources for calcium data

Calcium values for all survey foods and most ingredients were taken from the CSFII technical support files (2); calcium values for the remaining ingredient codes were from the NDB (20). Survey recipes were used to calculate total calcium values for survey foods and document ingredients of many food mixtures. Information obtained from the Nutrient Data Laboratory of the USDA Agricultural Research Service was used to develop estimates for ingredient amounts for mixtures such as condensed soup, which with water, appeared as ingredients in a survey recipe for soup, prepared with water. When necessary, ingredient data was obtained from the ingredient and nutrient information on food labels or other manufacturer data, using the procedure described by Marcoe and Haytowitz (22).

Determining Calcium From Foods And Ingredients

Total nutrients for each food or from mixture ingredients were determined by the retention factors method (23,24) using recipe ingredient amounts (grams and calcium mg/100 g ingredient). Retention factors from a file within the survey recipe database were applied to ingredients to estimate vitamin and mineral retention after cooking or processing. Recipe data also provided factors to adjust raw ingredients in recipes for cooked foods for moisture and fat changes (% gain or loss). The steps for the retention factor method are summarized by this formula:

$$\Sigma[(\text{ingredient weight in grams}) \times (\text{mg calcium per 100 g ingredient} \div 100) \times (\%\ \text{retention})] \div [100\% + (\%\text{moisture change}) + (\%\text{fat change})]$$

Grouping Protocols

Food and/or ingredient sources for calcium were grouped using four protocols: traditional (TRAD) (2,18), epidemiological (EPI) (6,7), pyramid (PYR) (14,15), and commodity (COMM) (17). There were five major food groups (dairy, grain, fruit, vegetable, meat-poultry-fish/alternates [MPF/alt]) in each protocol. Foods or ingredients that didn't meet the criteria for these major groups were assigned to "other foods." Foods assigned to other foods by one protocol were sometimes assigned to a major group by another protocol. For example, ice cream and pudding were assigned to dairy foods using the TRAD protocol, but to Other foods (desserts) using the EPI protocol.

Table 1
Food group definitions by grouping protocols identifying major sources of dietary calcium

Food group	Grouping protocol[a]	Calcium intake[b] (% total)	Major food and ingredient sources for calcium
Dairy	Traditional	48	Milk (flavored and unflavored), milk drinks (cocoa, milkshakes), yogurt, cheese; fluid and whipped cream, half-and-half, sour cream, cream cheese, infant formulas, meal replacements, and mixtures mainly dairy[c]. Excludes milk and cheese used as ingredients in mixtures not mainly dairy.
	Epidemiological	54	Milk, yogurt (not frozen), cheese, and infant formulas. Excludes milk from grain desserts and breads, milk desserts, and sauces.
	Pyramid	60	Milk, chocolate milk, yogurt (not frozen), cheese. Excludes milk from grain desserts and breads, and milk desserts.
	Commodity	63	Milk, yogurt (unflavored, not frozen), and cheese.
Grain	Traditional	27	Yeast breads/rolls, quick breads (biscuits, corn bread/muffins, nut and fruit breads-muffins, pancakes, waffles, tortilla/taco shells), French toast; breakfast cereals, pasta, rice; cakes, cookies, pastries, pies; crackers, flour, popcorn, pretzels, corn chips, and mixtures mainly grain[d]. Excludes grain used as ingredients in mixtures where grain is not a prominent ingredient.
	Epidemiological	17	Same as TRAD but excludes nut and fruit breads/muffins, grain desserts and pastries, corn chips, and popcorn; includes rice, pasta, flour and other grain ingredients from mixtures mainly grain or mixtures mainly MPF/alt[e]
	Pyramid	20	Same as TRAD except includes rice, pasta, flour, and other grain ingredients from mixtures mainly grain or mainly MPF/alt, and sauces.
	Commodity	16	Rice, flour, whole grain and bran, dry pasta; leavening from bread, cakes, and other baked products; added calcium from fortified/enriched cereal grains and fortified breakfast cereals.
MPF/alt	Traditional	11	Beef, pork, lamb, veal, game, organ meats, frankfurters, sausages, luncheon meats, poultry, fish, shellfish; meat gravies; eggs; dried beans and peas; nuts, peanuts, seeds; and soy products. Includes mixtures mainly MPF/alt; excludes MPF/alt used as ingredients in mixtures not mainly MPF/alt.
	Epidemiological	5	Same as TRAD except excludes meat gravies, dried beans and peas; includes MPF/alt ingredients from all mixtures.
	Pyramid	5	Same as EPI.
	Commodity	5	Same as EPI.
Vegetables	Traditional	6	White potatoes, dark-green and deep-yellow vegetables, tomatoes, lettuce, green beans, corn, green peas, lima beans, other vegetables; mixtures having vegetables as a main ingredient; and vegetable juices. Excludes vegetables used as ingredients in mixtures not mainly vegetables, and dried beans and peas.
	Epidemiological	7	Includes all sources of vegetables, including dried beans and peas and vegetables from mixtures.
	Pyramid	7	Same as EPI.
	Commodity	7	Same as EPI.
Fruits	Traditional	2	Citrus fruits and juices, dried fruits, and other fruits and juices; mixtures having fruit or fruit juices as a main ingredient. Excludes fruits used as ingredients in mixtures not mainly fruit.
	Epidemiological	2	Includes all sources of fruit ingredients except fruit in grain breads, cakes, pies, and breakfast cereals.
	Pyramid	2	Same as EPI.
	Commodity	3	Includes all sources of fruit ingredients from all mixtures.
Other foods	Traditional	5	Fats, oils, sugars, sweets, beverages (excludes milk drinks); cream substitutes, and gravy.
	Epidemiological	16	Same as TRAD, also includes dairy desserts, cream, cream cheese; nut and fruit breads/muffins, grain desserts, corn chips, and popcorn; broths and consomme, condiments, sauces, chips, and seasonings.
	Pyramid	6	Fats, oils, sugars, syrups, other sweeteners, seasonings, broth/consomme, infant formulas, cream, cream substitutes, and cream cheese.
	Commodity	7	Same as PYR except excludes broth/comsomme; includes food additives such as monocalcium phosphate (if estimates were available), and leavening when used in a mixture not traditionally assigned to the grain group (eg, bread pudding or pudding with vanilla wafers).

MPF/alt=Meat, poultry, fish, and meat alternates.
[a]Dietary sources for calcium identified by the Agricultural Research Service traditional (TRAD) grouping protocol (2,18) includes only US Department of Agriculture survey foods (n=9,394); epidemiological (EPI) protocol (6,7) includes about 3,000 survey foods and ingredients of more than 6,000 mixed survey foods; pyramid (PYR) protocol (14,15) includes about 2,000 survey foods and ingredients of more than 7,000 mixed survey foods; commodity (COMM) protocol (17) includes only the discrete foods or ingredients (n>1,000) from the 9,394 survey foods.
[b]Source: CSFII 1994-96, 98 (2); 18,071 persons 2 years of age and older; mean calcium intake=790 mg.
[c]Mixtures mainly diary includes cheese/white sauce, dairy desserts (ice cream, imitation ice cream, ice milk, sherbet, frozen yogurt, and other desserts made with milk, such as pudding, custard, and baby-food pudding); mixtures having cheese as a main ingredient such as cheese dips and cheese sandwiches coded as a single item; and flavored yogurt and yogurt with fruit.
[d]Mixtures mainly grain includes foods such as burritos, tacos, pizza, egg rolls, quiche, spaghetti with sauce, rice and pasta mixtures; frozen meals in which the main course is a grain mixture; noodle and rice soups; and baby-food macaroni and spaghetti mixtures.
[e]Mixtures mainly MPF/alt includes foods such as chicken cacciatore; beef loaf; chili con carne; venison stew; hash; tuna or egg salad; omelets; corn dog; baked beans; chicken or lentil soup; frozen meals in which the main course is an MPF item; MPF/alt sandwiches coded as a single item (for example, cheeseburger on a bun or peanut butter sandwiches); meat substitutes that are mainly vegetable protein; and baby-food meat and poultry mixtures.

Table 2
Examples of foods and ingredients assigned to grouping protocols used for reporting dietary sources of calcium

USDA survey foods	Ingredients in the survey food	Food groups (subgroups) by grouping protocol			
		ARS/Traditional	Epidemiological	Pyramid	Commodities
Milk	Milk	Dairy (milk)	Dairy (milk)	Dairy (milk)	Dairy (milk)
Bread	Flour, eggs, milk, fat, sweetener, yeast, water	Grain (yeast bread)	Grain (yeast bread)	Grain (yeast bread)	Dairy (milk), grain (flour, yeast), MPF/alt (egg), other foods (fats, sweetener, seasoning)
Cheeseburger	Beef, breads, cheese, lettuce, onion, tomato, catsup, mustard	MPF (mixtures mainly MPF)	Diary (cheese), grain (yeast bread), MPF/alt (beef), vegetables (onion, tomato, lettuce), other foods (fats, sweetener, condiments)	Dairy (cheese) grain (yeast bread), MPF/alt (beef), vegetables (onion, tomato, lettuce, tomato sauce), other foods (fats, sweetener, seasoning)	Dairy (cheese, milk), grain (flour, yeast), MPF/alt (beef, egg), vegetables (onion, lettuce, tomato, tomato sauce), other foods (fats, sweetener, seasoning)
White sauce	Milk, flour, margarine, sesoning	Dairy (milk sauce)	Other foods (sauces)	Dairy (milk, cheese), grain (flour), other foods (fat, seasoning)	Dairy (milk, cheese), grain (flour), other foods (fat, seasoning)
Macaroni and cheese	Pasta, cheese, white sauce	Grain (mixtures mainly grain)	Dairy (cheese), grain (pasta), other foods (white sauce)	Dairy (milk, cheese), grain (flour, pasta), other foods (fat, seasoning)	Dairy (milk, cheese), grain (flour, pasta), other foods (fat, seasoning)

USDA=US Department of Agriculture.
ARS=Agricultural Research Service.
MPF=Meat, poultry, fish.

These same foods were considered mixtures for the PYR and COMM protocols, thus, their ingredients were assigned to the appropriate groups in these protocols. Table 1 lists the major foods/ingredients assigned to groups within each protocol. Selected subgroups were included in the results if they provided at least 2% of total calcium intake for any sex/age group. This criteria is consistent to data presented by Subar et al (6,7) on dietary sources of nutrients. Table 2 provides examples of the group assignments by protocols for several foods; some assignments were the same across all protocols, others were different among two, three or four protocols.

Determining Dietary Calcium Contributions From Food Groups

A database created for each grouping protocol identified, per 100 g food, the amount of calcium from the food or its ingredients by food groups. These databases were joined with the CSFII intake records; two-day average calcium intakes by food groups in each protocol were analyzed using SUDAAN (release 7.5, 1997, RTI, Research Triangle Park, NC). SUDANN is a statistical package appropriate for the complex sample design of the CSFII. Sampling weights (2) were used to provide a nationally representative sample of noninstitutionalized persons residing in households in the United States, adjusting the sample for variable probabilities of selection and differential nonresponse. Sample weights also calibrated the sample to the national population along characteristics believed to be determinants of food intake, including such factors as age, race, ethnicity, income, employment status, and day of week. Group contributions were calculated as the population ratio of total calcium contributed by a specific group to the total amount consumed (25); sample weights were used for both totals.

The calcium contributions for each food group within each grouping protocol were tabulated for all participants two years of age and older, and by various sex/age categories. Population ratios were used, thus, tests for statistical differences among and between the groups were not appropriate.

RESULTS

Dairy Calcium By Protocols and Sex/Age Groups

This study provides the most current national estimates for calcium contributions from foods and/or their ingredients in US diets. Dairy foods have indisputably been the highest contributor of dietary calcium (3,4,6,7,18); thus, it was no surprise that this group remained the top-ranked source of calcium within each of the protocols used in this study (Table 3). When dairy contributions from each protocol were compared, the COMM dairy group ranked highest (63% for all persons) compared with contributions from the PYR (60%), EPI (54%), and TRAD (48%) dairy groups. The higher contributions using the COMM protocol represented contributions from all single-ingredient sources for unflavored milk, cheese, and yogurt from all survey foods, whereas, the TRAD protocol included calcium contributions from survey foods that were milk, cheese, yogurt, and dairy mixtures.

For all persons, the difference between the COMM and TRAD milk, cheese, and yogurt subgroup contributions was 21

Table 3
Percent contribution of food groups to total calcium intakes by grouping protocol

Food groups[a]	Protocol	Age (yrs):	All	<5	6-11	12-19		20-29		30-49		50-69		70+
		Gender:	MF	MF	MF	M	F	M	F	M	F	M	F	MF
		Mean (mg):	790	820	906	1,132	737	934	675	930	637	779	601	660
		% Pop:	100	6	9	6	6	8	7	16	16	8	10	8
			←					Percent[b]						→
Dairy	**TRAD**		**48**	**65**	**61**	**51**	**49**	**39**	**46**	**44**	**44**	**42**	**45**	**48**
	EPI		**54**	**68**	**65**	**63**	**58**	**53**	**54**	**51**	**50**	**45**	**46**	**47**
	PYR		**60**	**73**	**71**	**68**	**65**	**57**	**60**	**57**	**57**	**52**	**54**	**56**
	COMM		**63**	**75**	**73**	**70**	**67**	**60**	**62**	**60**	**60**	**56**	**58**	**59**
Milk	TRAD		31	52	47	37	33	23	27	25	25	26	26	33
	EPI		33	53	48	39	35	25	29	27	27	28	28	35
	PYR		40	59	54	44	42	29	35	34	35	36	38	44
	COMM		42	60	55	45	43	30	37	36	37	38	41	47
Cheese	TRAD		10	8	8	10	10	12	13	13	11	9	9	7
	EPI		20	14	16	23	22	28	23	22	21	16	15	11
	PYR		20	14	16	23	22	28	24	23	21	16	15	11
	COMM		20	14	16	24	23	28	24	23	21	16	15	11
Yogurt	TRAD		1	2	1	1	1	1	2	1	3	1	3	1
	EPI		1	2	1	1	1	1	2	1	3	1	3	1
	PYR		*	*	*	*	*	*	1	*	*	*	1	*
	COMM		*	*	*	*	*	*	*	*	*	*	*	*
Grains	**TRAD**		**27**	**21**	**25**	**30**	**31**	**33**	**28**	**28**	**28**	**27**	**26**	**25**
	EPI		**17**	**13**	**14**	**15**	**15**	**18**	**16**	**17**	**17**	**19**	**18**	**18**
	PYR		**20**	**15**	**17**	**18**	**19**	**21**	**20**	**21**	**20**	**22**	**21**	**21**
	COMM		**16**	**12**	**14**	**15**	**15**	**17**	**16**	**17**	**16**	**17**	**16**	**16**
Mixtures mainly grain[c]	TRAD		11	8	10	15	15	17	12	11	11	7	7	4
Yeast bread	TRAD		7	4	5	5	6	7	6	7	7	8	8	8
	EPI		8	5	7	7	8	10	8	10	9	10	9	9
	PYR		8	5	6	7	7	10	8	9	8	9	9	8
	COMM		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Quick bread	TRAD		3	2	3	3	2	3	3	3	3	4	3	3
	EPI		3	2	3	2	2	2	2	3	3	4	3	3
	PYR		4	2	3	4	3	4	4	4	4	4	4	4
	COMM		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Breakfast cereal	TRAD		3	4	3	2	3	2	2	2	2	4	3	5
	EPI		3	4	3	2	2	2	2	2	2	3	3	5
	PYR		2	3	3	2	2	2	2	2	2	3	3	4
	COMM		1	1	*	*	*	*	1	*	*	1	1	2
Desserts	TRAD		3	2	2	2	3	2	3	3	3	3	3	3
	EPI		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	PYR		2	1	2	2	3	2	2	2	3	3	3	3
	COMM		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Snacks	TRAD		1	1	1	1	2	2	2	1	1	1	1	1
	EPI		1	1	1	*	1	1	1	1	1	1	1	1
	PYR		1	1	1	2	2	2	2	1	1	1	1	1
	COMM		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Meat and meat alternates	**TRAD**		**11**	**6**	**6**	**10**	**10**	**15**	**12**	**14**	**11**	**14**	**12**	**11**
	EPI		**5**	**3**	**3**	**3**	**3**	**5**	**4**	**5**	**5**	**6**	**5**	**5**
	PYR		**5**	**3**	**3**	**4**	**4**	**5**	**5**	**6**	**5**	**7**	**6**	**6**
	COMM		**5**	**3**	**3**	**4**	**4**	**5**	**5**	**6**	**5**	**7**	**6**	**6**
Meat, poultry & fish (MPF)	TRAD		3	2	2	2	2	3	2	3	3	4	3	3
	EPI		3	2	2	2	2	3	3	4	3	4	4	3
	PYR		3	2	2	2	2	3	3	4	3	4	3	3
	COMM		3	1	2	2	2	3	3	3	3	4	3	3
Mixtures mainly MPF[c]	TRAD		6	2	3	6	5	9	6	7	6	6	5	4
Vegetables	**TRAD**		**6**	**3**	**3**	**4**	**4**	**5**	**6**	**7**	**8**	**9**	**9**	**9**
	EPI		**7**	**3**	**4**	**5**	**6**	**7**	**7**	**8**	**8**	**9**	**10**	**9**
	PYR		**7**	**3**	**4**	**5**	**6**	**7**	**7**	**8**	**9**	**9**	**10**	**9**
	COMM		**7**	**3**	**4**	**5**	**6**	**7**	**7**	**8**	**9**	**9**	**10**	**9**
Fruits	**TRAD**		**2**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**3**
	EPI		**2**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**3**
	PYR		**2**	**3**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**3**
	COMM		**3**	**3**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**4**
Other foods	**TRAD**		**5**	**2**	**3**	**4**	**4**	**6**	**6**	**6**	**6**	**5**	**5**	**4**
	EPI		**16**	**10**	**12**	**13**	**16**	**15**	**16**	**17**	**18**	**18**	**18**	**17**
	PYR		**6**	**3**	**3**	**4**	**5**	**8**	**6**	**7**	**7**	**7**	**6**	**5**
	COMM		**7**	**3**	**4**	**5**	**6**	**8**	**7**	**8**	**8**	**8**	**7**	**6**

Source: CSFII 1994-96, 1998, individuals two years and older (excludes breastfed children).
[a]See Table 1 for examples of foods by food group and grouping protocol.
[b]The standard errors of the percentages from the four protocols ranged from less that 0.05 to 1.8. The percentages may not sum to 100% due to rounding.
[c]Mixtures mainly grain and mixtures mainly MPF are classifications used by ARS to report CSFII intakes and are only assigned in the TRAD protocol.
*Percentage is between 0 and 0.5.

percentage points. The COMM dairy contribution (63%) was one and one-half times higher than the TRAD contribution (42%), demonstrating the importance of single dairy ingredients from mixtures as sources for dietary calcium. (The calcium contribution from TRAD milk, cheese, and yogurt subgroups was 42%; the TRAD dairy (48%) included contributions (6%) from mixed dairy foods such as flavored milk drinks, milk shakes, ice cream, pudding and custards, cheese sauces, and fondues.) Differences between the COMM and TRAD dairy subgroups by sex/age groups were between 18 and 24 percentage points for male or female adults over 20 years of age, and 13 to 17 percentage points for children two to 11 years of age.

Subar et al (6,7) identified milk, cheese, and yeast breads as the highest ranked dietary sources for calcium among persons from the 1989-1991 CSFII. These three dietary sources provided 73% of the dietary calcium (6) for children two through 18 years of age, and 61% of the dietary calcium for adults 19 years and older (7). Among persons from the 1994-1996, and 1998 CSFII, children two to five and six to 19 years of age obtained 72 % and 69%, respectively, of their dietary calcium from EPI milk, cheese, and yeast breads; adults aged 20 years and over obtained about 57% of their total dietary calcium from these three food groups. Enns et al (26) identified a downward trend from 1989-1991 to 1994-1995 in the consumption of milk and yeast breads among adults aged 20 years and over, with intakes of cheese increasing slightly. However, when Subar's findings and those of this study are compared, these trends identified by Enns did not affect the overall contribution of milk, cheese, and yeast breads to calcium intakes.

Other Major Groups Ranked by Protocol

Ranked sources of calcium from the other major TRAD groups, in descending order after dairy foods, were grains, MPF/alt, vegetables/other foods, and fruits. Grains remained the second highest and fruit the lowest-ranked source among the EPI, PYR, and COMM groups. Vegetables ranked third among the PYR and COMM groups. EPI vegetables and other foods contributed nearly the same proportion of dietary calcium as the second-ranked EPI grain group. This higher ranking of the EPI other foods included dairy desserts and other dairy mixtures that were assigned to the TRAD dairy group; ingredients of these dairy mixtures were assigned among the major food groups in the PYR and COMM protocols.

Grain Sources for Calcium

Calcium contributed from the grains group included calcium added for enrichment and fortification of flour, bread, and breakfast cereals and calcium from the leavening ingredients of baked products. The mixtures mainly-grain subgroup, assigned as a subgroup only within the TRAD protocol, was the largest source of dietary calcium among the TRAD grain subgroups. Calcium contributions from the ingredients of the mixtures mainly-grain subgroup were assigned to the appropriate groups in the EPI, PYR, and COMM protocols. The only *COMM* grain subgroup was for single-ingredient cooked breakfast cereals. Other single-grain ingredients, including grains from ready-to-eat cereal, grain snacks, yeast breads, quick breads, and grain desserts, were included in COMM grains.

Meats, Vegetable, and Fruit Sources of Calcium

Contributions to total dietary calcium among all persons were consistent for the Meat/poultry/fish subgroup (3%), fruits (3%), and vegetables (6% to 7%) for each protocol. Calcium contributions (2%) from MPF/alt (eggs, soy products, nuts, and seeds) subgroups were included only in the total MPF/alt group for each protocol. Contributions from vegetable subgroups (legumes, dark green leafy vegetables, starchy vegetables including potatoes, or deep yellow vegetables) were unremarkable because no subgroup contributed more than 1% of total dietary calcium. These results indicate that MPF/alt and vegetable ingredients from mixtures were not important sources for dietary calcium.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Calcium remains a nutrient of interest and concern because national data indicates that many fail to meet the recommended daily intake (RDI) (27), consume the recommended numbers of Food Guide Pyramid dairy servings (14,28), or frequently include dark green and yellow vegetables in their diets (18). Among the more remarkable results from this study were measurable contributions dairy ingredients from food mixtures made to dietary calcium from dairy foods. This capability to identify additional or diminished calcium contributions from ingredient sources hidden in mixed foods has been unavailable to researchers investigating the relationship of dairy calcium to athletic performance and diseases such as cancer, hypertension, and osteoporosis. For example, Leachman-Slawson et al (29) examined sources of calcium intakes from dairy foods, supplements, or other foods among collegiate athletes and determined that mixed dishes, along with dairy products, provided most of the calcium intakes among men and women athletes. However, the calcium contributions from the ingredients of mixed dishes were not reported by Leachman-Slawson. Angbratt et al (30) compared estimated calcium intakes among women 20 to 30 and 50 to 60 years of age based on responses to two food questionnaires: one asking only about consumption of dairy foods, the other asking about consumption of calcium-rich food groups and dishes (mixed foods) in addition to dairy foods. Their findings demonstrated that information based only on consumption of dairy foods was sufficient to determine who might be at risk for consuming less than the recommended calcium intake for their age. Shin et al (31) was unable to demonstrate an association between intake of dairy foods and breast cancer in postmenopausal women. Wu et al (32) reported that in descending order, vegetables, protein-rich foods (eggs and egg mixtures), dairy, soybean foods, and seafood were the main sources of dietary calcium in Asian diets. Mean calcium intakes of Asian adults 19 to 64 years of age were about 500 mg; the lower calcium intakes for males aged 20 to 24 years and females aged 25 to 34 years were attributed to lower intakes of dark green and yellow vegetables and dairy products.

Although data about calcium contributions from milk and cheese mixture ingredients can more completely identify dairy sources for dietary calcium, there are both nutritional and economic costs from consuming more mixtures with dairy foods. Many mixtures provide more fat and energy per milligram calcium compared with the amount of fat and energy per milligram calcium from milk and cheese. Likewise, mixtures are often a more expensive source of calcium than milk or cheese purchased separately (33,34). For some persons, an additional dairy serving (1 c milk, 8 oz yogurt, 1 to 1 ½ oz cheese) can raise calcium intakes to recommended levels (14,35). Other options identified for increasing calcium intakes include consumption of more calcium-rich vegetables and grains; cereals, milk, and juices fortified with calcium; and calcium supplements (27).

CONCLUSIONS

This study is unique in its ability to:

- Completely define all food mixtures by their ingredients;
- Quantify the calcium contributions from ingredient sources hidden in food mixtures, especially contributions from milk and cheese;
- Demonstrate the complexity of food grouping assignments when grouping criteria for food- or ingredient-level data are different in the protocols used; and
- Translate food data into an hierarchical database containing grouping protocols for aggregated information on foods, ingredients, and commodities.

The need for such a systematic approach to consistently translate national food survey data sources into other measures is needed to meet a variety of research objectives, including assessment of intake by Food Guide Pyramid serving recommendations, enhancement and development of dietary guidance materials with a deeper understanding of the dynamic role mixture ingredients make to intakes of specific nutrients, and economic and safety assessments of food intakes from potential contamination by chemical and biological materials. The existence of a food-ingredient-commodity translation database with grouping options would help all users of USDA food survey and nutrient databases update and manage data files for conducting ingredient and commodity level intake analyses, including any national, state, and regional survey using the USDA food codes.

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